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ECL 208A

THE SNOTRUK (A)

Snow truck
The snow-going equivalent of a half-ton pickup truck, the Snotruk weighs a half-ton, totes a half-ton, and can be carried in a half-ton pickup. Built by Nortrac Mfg. (Arnprior, Ont.) as a cargo carrier, it'll do 21 mph and crawl up a 60-percent grade.

The assistance of Mr. John Smeaton is gratefully acknowledged.

Prepared with support from the Department of Industry, Trade & Commerce. Published with support from the sponsors of the ASEE-Stanford Engineering Case Program:

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THE SNOTRUK (A)

Conception

In early 1970 John Smeaton and Fred Fassbender, the co-owners, began to consider the future of their company "Carleton Products Consultants Ltd." Their major consulting contract with Bolens was running out and they were faced with deciding what to do next.

John Smeaton had been chief engineer at Hus-ski Ltd., a Montreal manufacturer of recreation snowmobiles (Exhibit A-1), when Bolens of Wisconsin, a division of Food Machinery Corporation, purchased the company. The new management soon required that John undertake not only the development of new vehicles but the additional duties of General Manager and Plant Manager. Because of this John hired Fred Fassbender, who had worked with him in a previous enterprise, to join him as chief inspector. John and Fred formed a successful design and management team for Hus-ski.

In spite of the satisfactory operation of the Hus-ski plant in Montreal, Bolens closed it down in order to consolidate their product lines. The Bolens plant was manufacturing lawn tractors in the winter with slack periods in the summer. The Montreal Hus-ski plant producing snowmobiles was operating on the opposite cycle. The snowmobile manufacturing was therefore moved to Bolens in Port Washington, Wisconsin. It made good business sense but was disappointing to the people in Montreal.

Bolens was without snowmobile design experience at Port Washington and John Smeaton was asked to join the engineering staff in the U. S. The thought of moving to the U. S. had no appeal for John. Instead, he and Fred Fassbender decided to start a consulting firm which they called Carleton Products Consultants Ltd. Knowing that Bolens didn't have any snowmobile know-how, they proposed doing the snowmobile design and development for them.

The snowmobile development contract with Bolens became the backbone of their business. The terms of the contract required that Carleton Products Consultants Ltd. would, over a period of three years, develop snowmobiles for Bolens and at the same time train selected Bolens engineers. This work was lucrative but of finite duration.

Carleton Product Consultants Ltd. was located at Arnprior, Ont., a short distance from Ottawa where Fred Fassbender owned a farm. When incorporated in 1968, there were four people in the company. By 1970, approximately 16 people were involved. This growth had been largely due to the work carried out for Bolens. There were other customers of course but most of these contracts were small, in the order of $5,000 to $10,000 each. Fred and John had hoped that they would build up sufficient additional clientele in the first three years to give continuity to their operation, but the individual contracts were too small. In John's view, "You just can't hire and fire skilled people like we have on a casual basis. We had to have something with a little continuity. This meant manufacturing."

John Smeaton graduated in 1949 in mechanical engineering from the University of Toronto. He had always been interested in building and designing mechanical things. His academic performance had not been outstanding probably because as he remarked, "The more I learned at school the further I seemed to be getting from the mechanical things I loved."

Before joining Hus-ski, John had worked for the Ford Motor Co. of Canada, The Canadian Army Vehicle Development Establishment in Ottawa, and for John Gower, the inventor of the first six wheeled ATV (All Terrain Vehicle), the Jigger. He had also taken a flyer at his own business, "Pengor", an unsuccessful attempt to manufacture and market a recreational ATV, the Penguin. John speaks fondly of these experiences and feels they were all important in his development as an engineer, designer, and entrepreneur.

Fred Fassbender came to Canada in 1953 from Germany. In Germany he had studied as an agricultural technician. Fred, after working at a number of jobs in Canada, eventually bought his own farm near Arnprior. In 1964, Fred worked for John at Pengor and eventually rejoined him at Hus-ski.

The two men, over the years, had worked out a mutually compatible arrangement. Each has been able to pursue his own interests within their joint venture. John likes to design, invent and make things; Fred prefers to deal with customers, to do field service work and to look after the administrative side of the business.

With the Bolens contract coming to an end, John and Fred decided that if they were to continue in business they had better get into manufacturing something which would provide a cash flow and thus continuous employment for the staff.

With their backgrounds, it seemed a natural to consider building some form of snowmobile. There were approximately 110 firms already marketing recreational vehicles. Fred and John decided the market would soon be saturated and it would not be wise to attempt to compete in an orthodox way. Besides, to successfully market a recreational vehicle, a system of dealerships had to be set up with all the accompanying headaches. They looked for a specialty snowmobile in which they would have an advantage with their design skills, in which they would not have to rely on a system of dealerships, and in which the larger manufacturers, such as Bombardier, could not compete.

Snowmobile racing had become a continent wide sport. They considered designing and building a racing snowmobile equivalent to a sophisticated sports car. The snowmobiles used for racing were no more than souped-up versions of standard production vehicles. According to John, "Even today, there is no equivalent to the 'Lotus' in snowmobiles. There could be. Our idea was to create something for the 'cream' market, at a high price and low production rate for those people who could afford and would be willing to pay for performance. We knew we couldn't compete with Bombardier or Arctic Cat in what they do. On the other hand, they can't do justice to sophisticated low production specialty units. They just don't think that way."

The other alternative considered and the one finally adopted was a commercial working vehicle. During the development of the Hus-ski snowmobiles, Fred had been to the Arctic on various occasions for testing. There he had noted a need, but not yet a demand, for a small sturdy vehicle, roughly the snowmobile equivalent of the pick-up truck. Bombardier was making very heavy industrial machines weighing 3500 lbs. and costing $6500 plus they were also producing the small recreational snowmobiles. Nobody was making or selling a small general purpose work vehicle.

John describes how they went about establishing the vehicle requirements. "First we did a product survey. We sent out questionnaires (Exhibit A-2) to potential customers, such as Bell Canada, Ontario Hydro, mining companies and government departments. This questionnaire was supplemented by many personal calls by Fred. The results were good. Out of 50 questionnaires, we received 29 replies. When we put it all together there was almost unanimous agreement on what was wanted. The questionnaire of course, had to be intelligently drawn up to bring out the important specifications.

"What we wanted was a snowmobile with a flat bed capable of carrying more than 500 lbs. The vehicle could have a top speed of 20 mph. Durability was paramount. Everyone was insistent that the vehicle must be more durable and reliable than existing recreation snowmobiles. The physical layout was consistently specified as a flat bed, side by side seating, twin tracks and twin skis for steering. The expected range was 80-100 miles. They also wanted to be able to fit and carry the vehicle on the back of a pick-up truck. Finally, the price had to be less than $2,300."

Starting with these requirements, John prepared perspective sketches of possible designs. Fred took the best of these (Exhibit A-3) to various customers around the country. From their reactions, the discussions and his sense of the market, Fred made an estimate of the potential market for the vehicle. The total North American market for a snowmobile of the type they proposed could be about 4000 units a year.

This reflects the division of labor between Fred and John. John carried the responsibility for the design and production of the units. Fred did the marketing and evaluation of feedback from the customers. It was Fred who decided whether a customer complaint was to be handled by additional design effort or by additional customer education.

John took the most favored configuration and proceeded to design the vehicle they decided to call the "Snotruk".

He approached the design of the Snotruk in a straightforward manner. His first sketches had given the basic concept and showed what the vehicle would look like. He developed these further by making a 1/16th scale sketch, using the 95 percentile Arctic clothed man to establish proportion (Exhibit A-4). This gave him an overall feel for what the vehicle was about. When he was satisfied with this, he made his first formal drawing, a 1/10th scale drawing (Exhibit A-5). This scaled drawing was used to make his weight calculations and to determine weight distribution.

From the beginning it was assumed that a large number of the components would be purchased proprietary items. Of course, the chassis would be fabricated. The use of proprietary parts permitted rapid decision to be made on layout.

Weight distribution is an important factor in snowmobile design. "If you have too much weight on the skis and not enough on the track, you'll not have sufficient traction, but if you have too much weight on the track and not enough on the skis you won't be able to steer the vehicle."

From the scaled drawing came the final pictorial sketch which looked very much like the finished design (Exhibit A-6).

Cost estimates were made from the layout without completing detail design. The cost estimates were based on the cost of the purchased components and the labor costs for the items to be fabricated. Fred made some projections as to the size of plant and support staff that would be needed and established an overhead. Starting with a desired selling price of $2500, he determined the production rate necessary to break even.

The break even production rate turned out to be 150-200 units a year. The decision to go ahead with the venture was taken at this point. "We knew we couldn't hope to sell anywhere near the potential 4,000 units. It would require a major marketing effort, with dealerships all over the continent. We didn't have the necessary marketing skills and probably couldn't acquire them in time. But it did seem to us that we could safely make, sell and service 200 units a year from our home base. Being first in a market we hoped we could quickly reach this sales rate and maintain it long enough to become established. We decided to go ahead and put our money into it.

"If we're successful, we expect that we will have competition. Competition will be free advertising for us. Besides, people should have at least two units to choose from. Since we only need to build 200 a year to break even, we're not depending on an exclusive market. We won't even mind being the underdog in terms of volume sales, in fact, in some cases it's an advantage. Our market strategy is to give outstanding service to a limited number of customers."

Once the decision was made to proceed and the cost established, Fred and John were faced with the problem of how to raise the additional funds to undertake the development. They had started the project in March 1970. By September they had the market survey completed and the first prototype running. Before they could go any further they needed additional funding.

A new company, Nortrac Mfg. Ltd., was founded to undertake the development, manufacturing, and marketing of the Snotruk. There were several reasons for using a new firm. Carleton Products Consultants Ltd. had developed an image and reputation as a design-research oriented organization. This might prejudice customers who are looking for a reliable working tool. The new company would be able to raise additional money for the development of the Snotruk without committing control of Carleton Products Consultants Ltd. or its assets.

As well, the new firm allowed John and Fred to offer stock options to selected employees. Finally, it was felt that a DREE (Department of Regional Economic Expansion) grant could be received for establishing the new manufacturing company in the Arnprior area.

"The major entrepreneurial problem is to find the capital. You soon find yourself tailoring the job to the capital available which isn't always the most economical" said John. "We couldn't have done the development without the PAIT and DREE grants. Our total starting costs including tooling, setting up the plant etc., came to about $125,000. The grants covered about half of this; some money was raised from local business men but a good part of it was in the form of personal loans by Fred and myself, some as cash and some as time without pay. This is also part of entrepreneurial activity: from time to time you don't take home any pay. We put in 4 or 5 months without pay, which was tough. It can be demoralizing because you are not sure whether it will pay off in the end. We had a couple of good people with us who were receiving stock in lieu of pay, who couldn't stick with it and dropped out. We couldn't blame them."

Before the first prototype was complete, John and Fred applied for a PAIT grant. PAIT (Program for the Advancement of Industrial Technology) is a program of the Canadian government administered by the Department of Industry, Trade and Commerce. Its objective is, through shared costs (usually 50%), to encourage industrial growth and production in Canada by supporting the development of new or improved products and processes for commercial markets. Under the terms of the grant, Nortrac had to demonstrate that they could raise 50% of the projected development cost of $90,000. This they did by selling shares and obtaining personal loans. The application was made in September and was approved in December. By the time the first grant payments were received, $60,000 had already been spent. For this, John had to draw on his reputation. "As long as you are straight with people, if you tell them what the risks are and if you tell them what the prospects are, they will usually back you. If things go wrong, they may not love you but they will usually be prepared to deal with you again." With this approach, Nortrac was able to get extensions from its suppliers through the difficult periods.

Thus, the newly incorporated company, Nortrac Manufacturing Ltd., undertook the development, manufacturing and sales of the Snotruk. John and Fred were committed.

Bolens Snowmobiles

EXHIBIT A-1

Hybrid vehicles are emerging as a district product class that combines the capabilities of snowmobiles and ATVs.

Reprinted from MACHINE DESIGN,
Feb. 4, 1971

Sports Success for the Seventies?

Snowmobiles

MARK D. ZIMMERMAN *Associate Editor*

SNOWMOBILES ARE SLEEK STEEDS that are moving from the hinterlands to suburbs, becoming fancier and safer, and getting versatile enough to be used outside of traditional seasons and geographic areas.

The phenomenal success of snowmobiles is attributed to a widening use of improved plastics, an availability of compact, high-output engines, and the unleashed demand for winter-time mobility. All factors converged in the early '60s, launching snowmobiles as the focus of a major outdoor sport and a fast-growing industry. Over 60 vehicle builders expect to generate about a billion dollars in snowmobile sales this season.

Hoping to prove that snowmobiles have earned a definite niche in recreational spending—and are relatively insensitive to economic downturns—snowmobile makers peg 1970-71 sales at 600,000 units. This is up 19% from 1969-70 sales and is a step toward the million units per year volume predicted for 1975. Factory sales totaled only 8,000 snowmobiles in 1964; the current vehicle population is estimated at over a million units.

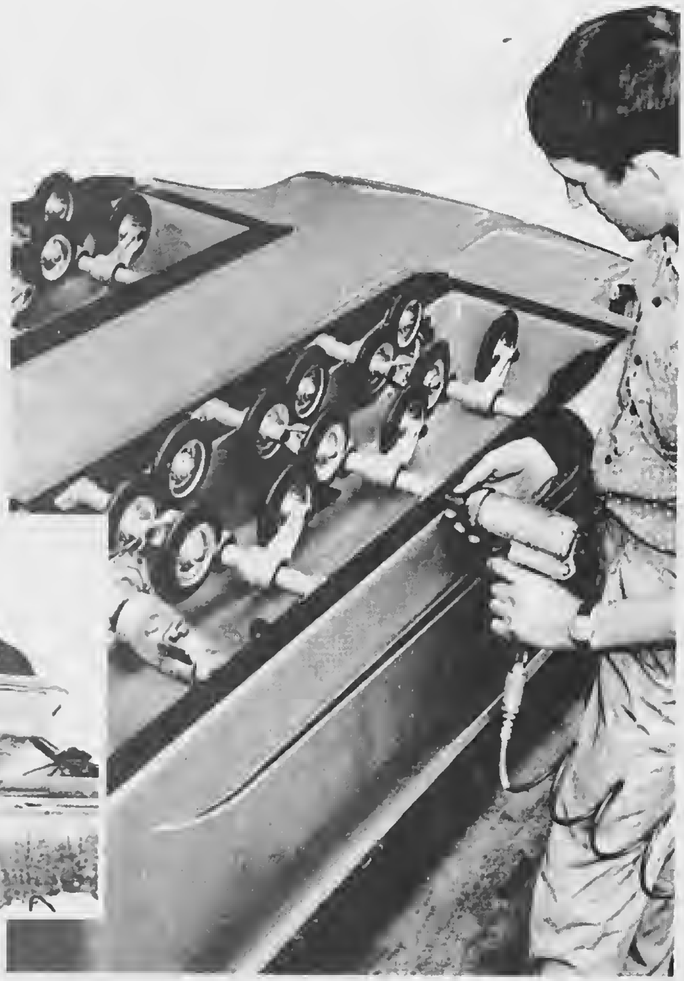
The economic impact of snowmobiles is further bolstered by the rising popularity of racing, increasing rental programs and agencies (often in or near cities), and growing number of snowmobile clubs. Factory-sponsored racers and teams are said to have a large influence on the market, a "race 'em on Sunday and sell 'em on Monday" technique borrowed from Detroit. Snowmobiles now run regularly at New York's Monticello Raceway, site of harness racing in the "off season"; in the Winnepeg to St. Paul "500"; and in many other events.

Snowmobile production is split between U. S. and Canadian firms, and includes such major builders as Bombardier, Arctic Enterprises, and Polaris. The lucrative market has attracted motorcycle builders such as Harley-Davidson, Suzuki, and Yamaha; outboard motor makers such as OMC (Johnson and Evinrude) and Kiekhaefer Mercury; outdoor products producer, Coleman; farm equipment builder, Massey-Ferguson; lawn and garden equipment makers such as Bolens, Gravely, and Wheel Horse; and corporate conglomerates such as Bangor Punta.

A diversity of snowmobile uses and customers has prompted numerous special designs. Large, medium, and small-size

EXHIBIT A-1

Two and three-machine families account for the rising popularity of compact and special-design snowmobiles.



Bogie-wheel suspensions and cleated rubber or plastic tracks from 7.5 to 30-in. wide prevail in snowmobiles.

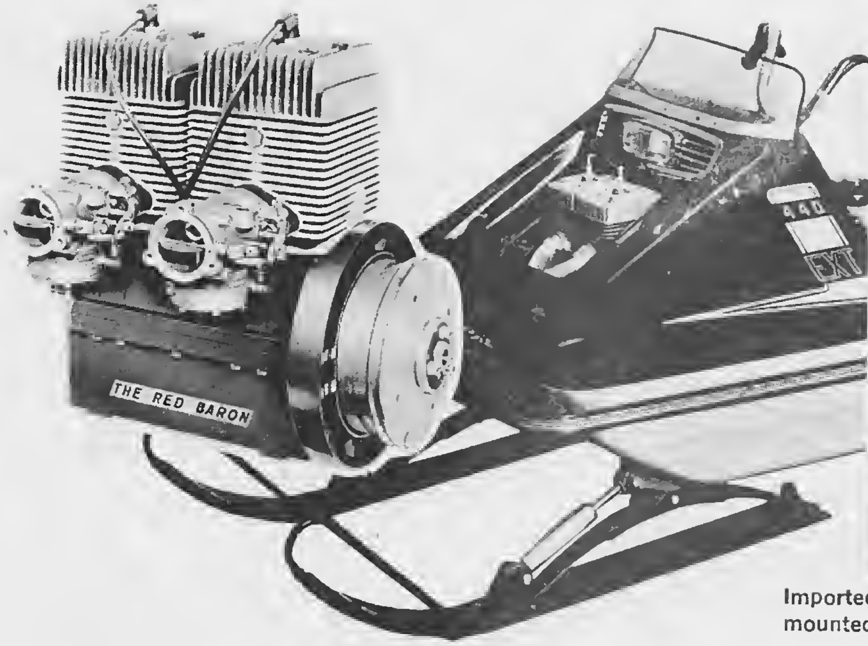
machines are now available, ranging from low-cost, economy units up to sporty, high-performance machines. Some vehicle builders are trying to bridge seasonal and geographical gaps with hybrid designs for year-round use and for buyers outside the snow belt.

Hybrid Vehicles: This new, fast growing product class fits between snowmobiles and ATVs. For example, Tracker models are built with two 10.5 or 15.5-in.-wide tracks and have front skis that interchange with wheels for off-season use. A Hornet model accommodates four wheels while its rear track stays intact; similarly, the Sno-Pony converts to a three-wheel ATV. The Scatmobile has three in-line, high-flotation tires instead of a track and, like Trackers, skis that are exchanged for wheels. An increasingly popular group of hybrids is built only with twin tracks and includes such models as the Nanuk, Playcat, Ridge-Runner, and Snow Eagle.

Multimachine Families: Two and three-snowmobile families are prompting the emergence of compact, family, and small sport models. Snowmobiles designed especially for youngsters, women, and older persons are generally less powerful, easier to operate, and less expensive than standard machines. Examples: Yard-Man's Sno Cub, with 10.5-in.-wide track and 4.2-hp engine; Sportcraft's Swinger, with 12-in. track and 10-hp engine; and Polaris's Playmate, with 12-in. track and 12-hp engine.

One of several new snowmobiles for 1970-71 is Leisure Vehicles' Raider, a rear-engine machine with two 7.5-in.-wide tracks and a 22-hp engine. Departing from motorcycle-based designs, the Raider and a 10-hp companion model, the Roamer, have sports-car profiles because engineers Bob Bracey and John Drawe previously worked for Kar-Kraft and designed the body of Ford's Mark II-GT which gained racing fame at Le Mans.

Two-Cycle Engines: Foreign-built engines are mounted in 75% of currently available models of snowmobiles. Designed with one to three cylinders, 99 to 793-cc displacements, and 4.2 to 80-hp outputs, the engines are built by JLO, Kawasaki, Lloyd, Rotax, Sachs, Solo, Suzuki, and Yamaha. Included are Fuji and Hirth powerplants which are "captive imports" of Polaris and

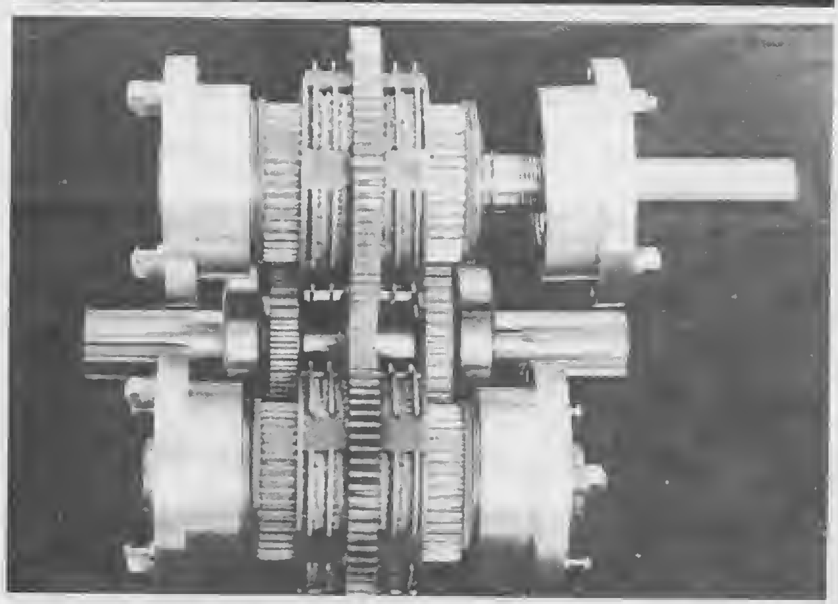


Imported two-cycle engines of 4.2 to 80 hp are mounted in about 75% of snowmobile models.

Teledyne Wisconsin, respectively, and rotary-combustion engines built by Fichtel & Sachs.

Domestic engines carry the names of Bolens, Canadian Curtiss-Wright, Chrysler, Kohler, Mercury and, new for 1970-71, a four-cycle Briggs & Stratton unit and two McCulloch models with piston-type counterbalances and pumps. Engine power ratings can vary widely for a given displacement: an engine may produce its baseline power with one carburetor, deliver 16% more power with a different carburetor, develop 25% more power at a higher speed with a slightly tuned muffler, and produce 35% more power with a highly tuned system.

Variable-Speed Drives: The torque converters of most snowmobiles consist of a V-belt and a pair of centrifugally actuated, variable-pitch sheaves. Some are speed-sensing, some torque-sensing; some are engineered by component suppliers, others by vehicle builders; and some act as the drive clutch. The shaft carrying the torque converter's driven sheave usually incorporates the brakes—disc, wedge, or shoe-type—and a sprocket. A roller chain and a track-drive sprocket are next in the drive sequence, along with sprockets or lugged wheels that engage and drive the tracks.



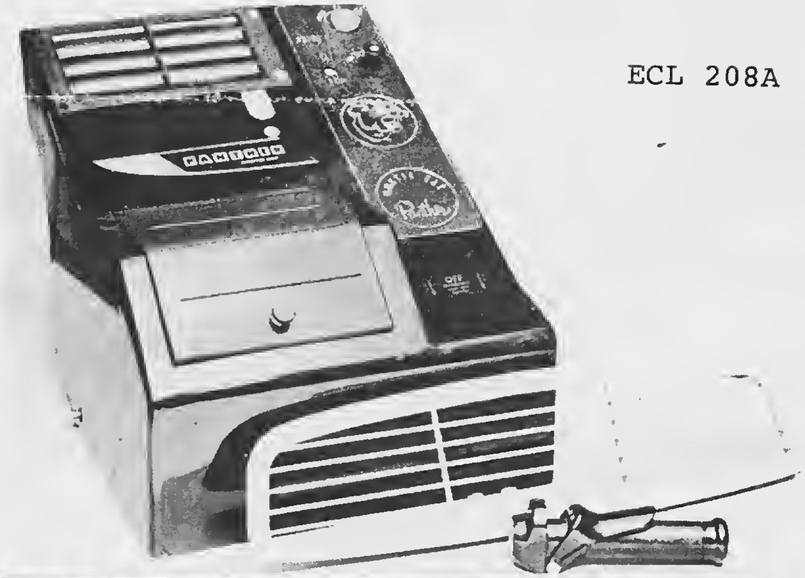
Gear-type transmissions are used increasingly to complement variable-speed, belt-type torque converters. Unit shown is for a twin-track hybrid vehicle.

Because few snowmobiles have gear-type transmissions, tilt/swivel trailers have evolved for hauling the machines. The trailer beds tilt rearward for loading, but swivel around 90° and tilt forward for unloading since most snowmobiles only go forward. But more sophisticated transmissions are emerging, such as a new unit developed by Reuter for the Ridge-Runner, a twin-track hybrid design. The transmission provides forward, neutral, and reverse operation of each driven track.

Suspensions and Tracks: Each track may consist of one, two, or three belts that are endless or spliced. Some have molded tread, some riveted steel cleats; some have drive slots, others internal lugs. Tracks are made of rubber, polyester, urethane, fiberglass-reinforced nylon, or other materials. Torsion-type mounts for bogie wheels include rubber and steel springs; some machines have slide rail-type suspensions.

Track width is an indicator of snowmobile size and capability: compacts are 13-in.-wide or narrower; standard units, 14 to 17.5 in.; and wide-track models, 18 in. or more. Compacts are low-power, family models and, often, the back-up units for two-snowmobile owners. Wide-track machines are for cross-country operation and improved mobility in deep or soft snow. Deluxe and sport or racing models are usually bigger machines. Single-track snowmobiles have 10.5 to 30-in.-wide tracks; twin-track units have 7.5, 10.5, or 15.5-in.-wide tracks.

Plastic Parts: Plastics figure prominently in the design of hood shrouds, dashboard consoles, grilles, windscreens, light housings and lenses, wheels, control fittings, back-rests, and tracks. Thermoplastics, such as ABS and polycarbonate, and reinforced plastics, molded by spray-up or matched-die processes, are commonly used for hood shrouds. This highly styled part of snowmobiles must resist impact damage at subzero temperatures, tolerate engine heat and vibration, and carry the distinctive markings of each make.



An average snowmobile contains 50 to 60 lb of plastics, which is about 15% of vehicle weight. Thermoplastic and FRP hood shrouds are common.

Accessories: The profusion of goodies for snowmobiles includes protective cabs, towed passenger and/or freight sleds, track studs for ice, conversion kits for nonsnow operation, tachometers, speedometer/odometers, electric starters, transistorized ignition systems, fuel gages, gas priming kits, auxiliary fuel tanks, tuned exhaust systems, engine power-modification kits, shock absorbers, jacks, helmets, and apparel. Most are offered as proprietary items in major lines of snowmobiles.

All is not bright on the snowmobile horizon, however. Tough sledding looms ahead for vehicle makers as conservationists, police, doctors, legislators, and the public become increasingly aroused over the harassment of wildlife, vandalism, accidents, and noise. The noisy machines are banned in some parks; special trails are set aside for snowmobiles in others. Bizarre injuries are prompting critical looks at snowmobile design. Machines in Minnesota are subjected to a noise-level restriction (85 dbA at 50 ft) that is used in California for motor vehicles.

Despite the horsepower race of recent years, snowmobiles have naturally developed into safer machines. Manufacturers are focusing attention on styling and basic design, emphasizing functional vehicular improvement and greater dependability. One maker is funding university research on how snowmobiles affect winter ecology. Most firms are cooperating with states in developing vehicle licensing and use-regulation programs. Working through their trade association, snowmobile makers are staging an intensive educational campaign on product safety. And work is steadily progressing toward quieter machines.

SURVEY ON "SNO - TRUCK"

April 7, 1970

Department: average of 8 !

(1) Dimensions 9' long, 3.5' to 4' wide,

(2) Weight 425 lbs. (fear of having to manhandle)

(3) Seating 2 normal, but 3 to 4 possible.

(4) Payload 470 lbs. (varies from 150 to 1000 lbs)

(5) Pull 740 lbs (varies from 100 to 2000 lbs)

(6) Speedrange Road: 30-35 MPH, Bush: 5-10 MPH

(7) Reverse yes

(8) Tank 5 hrs at 3/4 throttle or better.

(9) Winch yes, 100' prefered, frontmounted,

10) Lights 2 Headlights, one adjustable, taillights, signallights search or trouble light desirable

11) Colour in good contrast to snow - bright colours,

12) Instruments fuelgauge, heatgauge for engine, cigarette lighter to be lit up at nights,

13) Horse Power 25 - 30

14) Decibels 84 or better

15) Cylinders 2 prefered or 4 if automotive

16) Watts similar to car

17) CC'S unimportant except for consumption.

EXHIBIT A-2

Survey on "Sno-truck": Pg 2

18) Electricstart: yes, but also recoil c̄ emergency rope,

19) Engine (make or kind) aircooled, automotive for long life,

20) Turncircle with reverse 12'–15', 20'–40' without, short desired

21) Sidehill safe! better than Alpine,

22) Grade better than Alpine

23) Suspension (wheels, slides) bogy wheels

24) Trackbelt (molded or constructed) cleated if dependable and not digging in easy, performance important

* 25) Materials (preferred in construction) Fibreglass and steel

26) Most important quality Reliability,

27) Next important quality steering control, pulling capability.

28) Comfort shielding from wind, cabing, good seats, heat.

29) Life 3.5 years (from 2 years in arctic to 5 years occasional use)

30) Repair 25% of purchase price over lifetime (not incl. accidents)

31) Service every 3 weeks or 80–100 hrs.

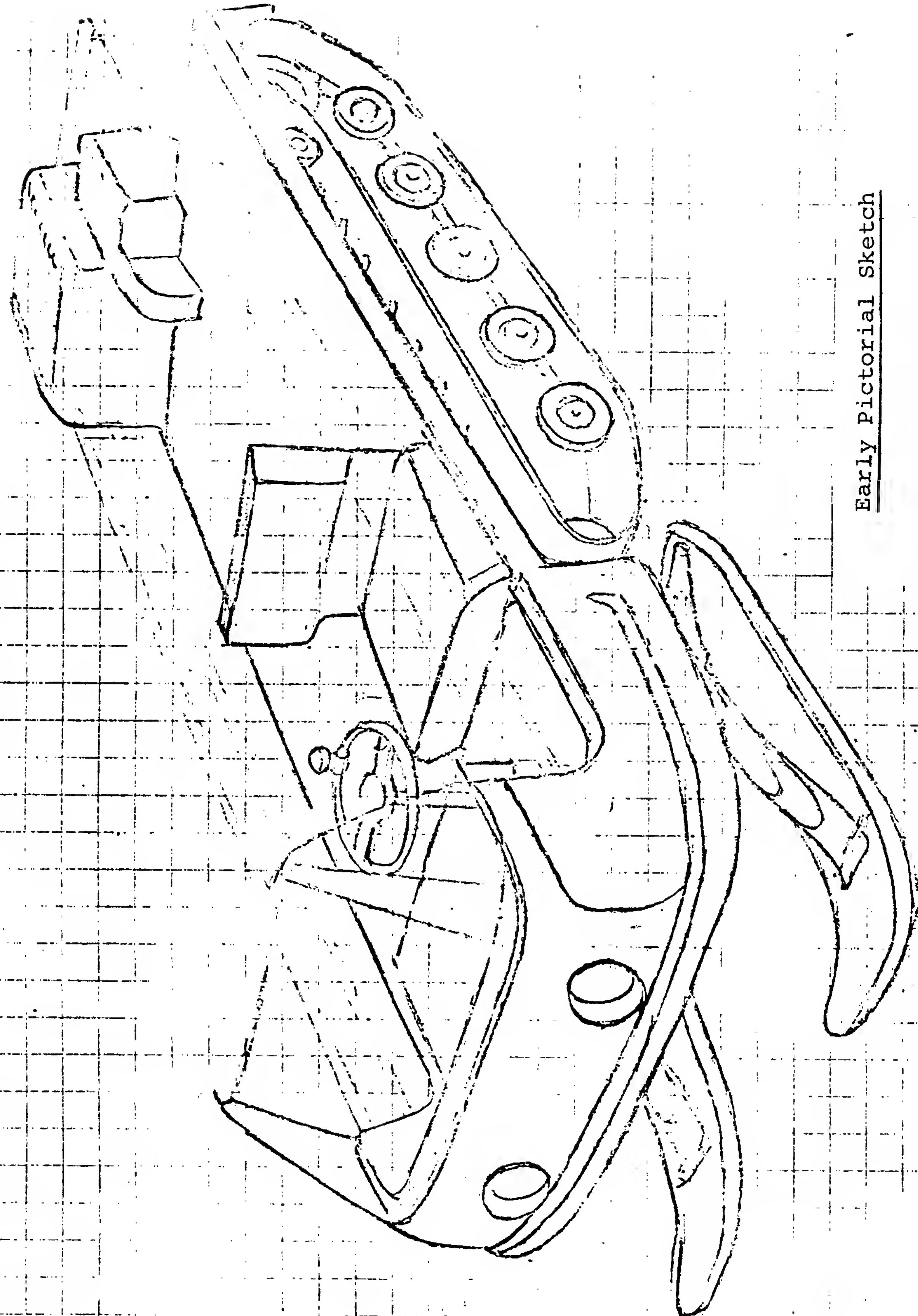
* 32) Price $1,700.00 to $2,225.00

33) Available A.S.A.P.

34) Comments

* 1.) Must fit into ½ ton long box with tailgate down,
* 2.) Steering sitting possible,
3) Must float on snow,
4) ease of maintenance – not too much welded together, simple,
* 5.) two skis with good runners
6.) safety is important, (rollbar)
7.) Top speed of least importance
8.) Good towhitch arrgt, strong! (jerks)
splicing must be possible,

EXHIBIT A-2



Early Pictorial Sketch

EXHIBIT A-3

SNO TRUK

Track Area 2000 in^2 Ski Area 400 in^2

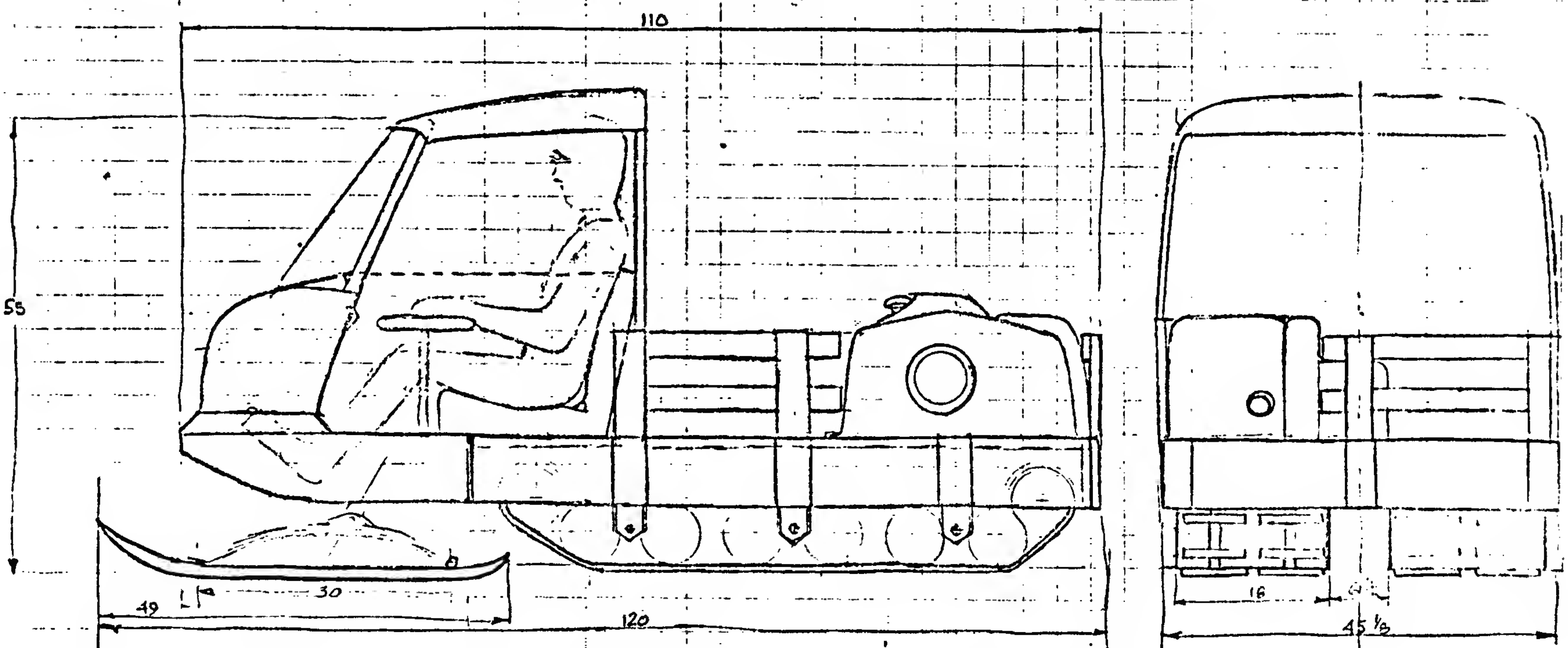
Weight (Net) 650 lbs

G.V.W. 1300 lbs

Ground Pressure (Loaded) .54 lbs $/in^2$

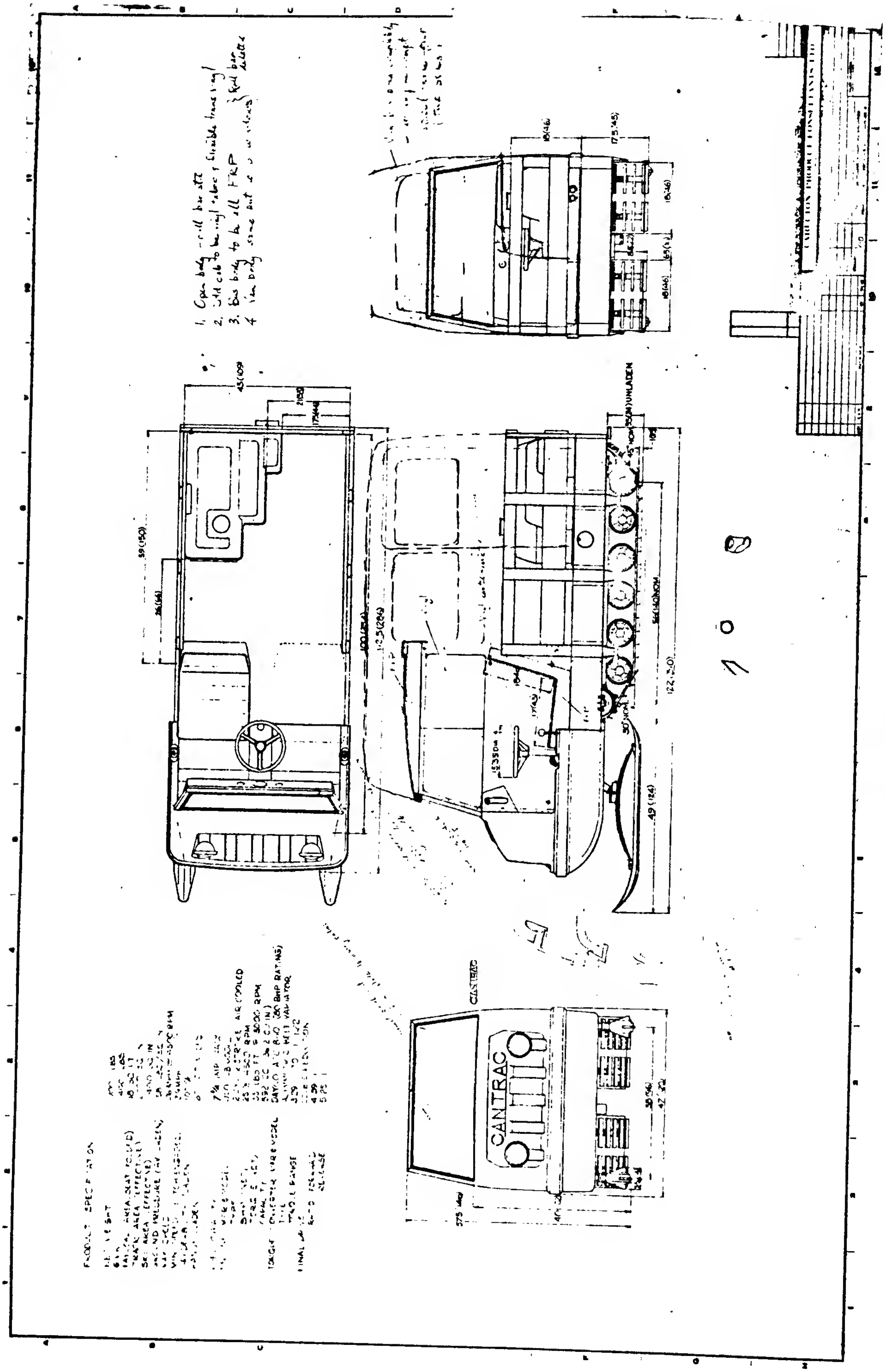
4

$\frac{1}{16}$



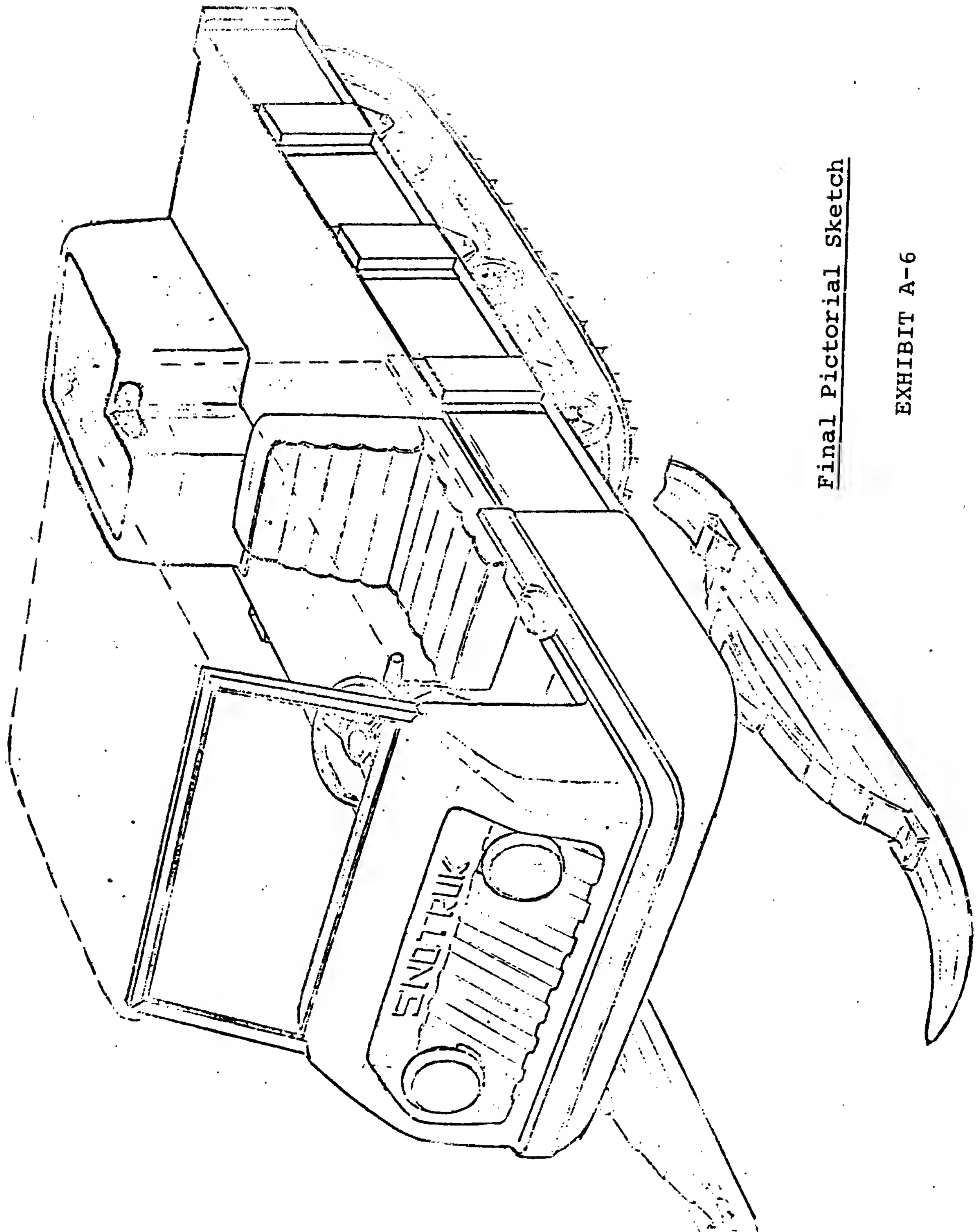
Sketch Layout

EXHIBIT A-4



Scale Drawing

EXHIBIT A-5



Final Pictorial Sketch

EXHIBIT A-6

THE SNOTRUK (B)

Basic Design and Development

For the design of the Snotruk, John Smeaton had the requirements well established by the market survey. It was to be a snowmobile but neither its appearance nor its performance was to be what is normally expected of the familiar recreational snowmobile. The recreational snowmobile is a high spirited exciting vehicle to drive. The Snotruk was to be a slower but more reliable working tool.

The first sketches and layouts had set the basic configuration of the vehicle. For John versatility was an added criteria. "Right from the beginning our idea was to produce a basic platform which could be modified to meet the specific requirements of different users by means of simple modification kits. These kits would convert our flat chassis to an ambulance, a freighter, a passenger vehicle, a recovery vehicle, etc."

Drawing on his extensive experience in snowmobile design, John undertook the detail design. It was to be a flat plywood bed on a welded steel frame with side by side seating up front. Steering was by means of a steering wheel operating twin skis through a simple linkage. A two stroke engine was to be located in the right back corner. The engine was to drive a two speed transmission through a torque sensing variable speed V belt drive. There would be two speeds forward and one reverse. A direct drive chain would drive the track sprocket. The brake would be on the drive shaft of the gear box. The track system, like other snowmobiles, would be of standard industrial belting with simple bogie wheels running on the belt to support the vehicle.

John makes no pretense at doing sophisticated analysis but he does insist upon some analysis on everything that he does. "I like to do what analysis I can. Then when we build a prototype and test it, if something doesn't work or breaks down I can then go further and find out what the problem is and fix it. This way you go about systematically developing a product. Mind you, you have to be careful that the systematic analysis doesn't stifle inventiveness. A good designer should balance creativity, analysis and experience."

Thus John's final design was accomplished through a process of design, analysis, testing and more analysis. "I didn't really arrive at the final design full blown. The four prototypes were the answer to eliminating the worst of the design problems."

The detail design was tackled one item at a time. "In designing the vehicle all I did was break it down into systems: The frame, the running gear, the suspension, the brakes, etc. Each could be treated as a separate system. The design of each was a straight forward design exercise. By working through all of these systems, we could be sure that when we had finished, the vehicle would be complete."

Although many components were expected to be purchased, John knew from the very beginning that he would have to design the main frame. From the layout (Exhibit A-4), the frame details were drawn (Exhibit B-1). It consisted of a main spine with a double frame to box in the tracks and to provide a frame to which the plywood platform would be attached. The analysis was simple but sufficient to determine the necessary sizes for the prototype. "Starting with a target gross vehicle weight of 1000 lbs. and possible 25% overload we did simple bending moment calculations. These indicated that the metal wall thickness wasn't critical with respect to bending or twisting of the frame. The problem would be buckling of the webs. Since we didn't have any sophisticated facilities to analyze exactly where, we decided to build the first prototype according to our sketch and see where buckling would take place on test.

"The sketch of the frame shows the weight calculations. When designing a vehicle to float on snow you must be very careful of weight. Our original objective was a total frame weight of 125 lbs. Our frame came to 98 lbs. With the addition of the plywood deck weighing 40 lbs. it came out 15 lbs over the target. For the first prototype, we went with that."

The metal thicknesses were simply chosen on the basis of fabrication techniques. Where the frame could be spot welded, 20 ga. steel was specified. Elsewhere 18 ga. and 16 ga. was specified for shielded arc welding.

The frame of the prototype was made directly from the sketch. The technician who fabricated the frame, eventually made the detail shop drawing. This drawing was then used for making subsequent prototypes and the production units.

When the first prototype was tested, various points on the frame buckled. These were strengthened by the addition of "doublers" and the drawings were changed to reflect this. With the addition of a few doublers, the frame stayed essentially the same throughout the development.

The skis were modified, purchased components. The ski springs were of a simple leaf spring pinned at the back and sliding in a channel at the front (Exhibit B-2). John designed the spring using a simple nomogram published in a magazine. This needed no change throughout the development.

The steering mechanism was a Bolens garden-tractor gear box, with simple linkages using standard snowmobile ball joints. This worked on the first prototype but not well. Eventually the width of the steering rack and pinion was increased and repacked in grease and automotive type ball joints had to be used. Then the steering mechanism was satisfactory.

The Snotruk included a novel arrangement of track bogies. John's experience at Pengor had led him to believe that the steering characteristics of the snowmobile could be improved if the tracks were slightly tilted up toward the front so that when the vehicle is running on hard packed snow or ice, the vehicle would be sitting on the front skis and the rear of the tracks only. This would cause more of the weight to be carried on the skis making them dig into the hardpack, giving greater steering effect. When the vehicle is riding on soft snow, the tracks sink into the snow and the load is distributed uniformly over the entire track reducing the ground pressure, the redistribution reduces the load on the front skis which have sufficient traction in the soft snow at the lower load. This was tried on the prototype (Exhibit B-6) and it worked as expected.

To accommodate the tilted track, the springs on the rear bogies had to be stiffer than on the remaining bogies, since they carry larger loads on hardpack. To achieve this in the same space, John simply uses square-wire torsion springs on the rear bogies in place of the round-wire torsion springs on the remaining bogies (Exhibit B-3).

With a required drawbar pull of 1400#, John paid special attention to traction. With recreation vehicles, the ability to pull additional items is not necessary but with an all purpose vehicle such as the Snotruk, the ability to pull accessories is essential. "We fabricated our tracks from conveyor belting as do many snowmobile manufacturers. The unique thing about our track is that we use our own design of grouser (the cleats on the track)." John explains, "When I was working for the army, I was told about the work of Dr. Kamm. His tests had shown that the best form for a grouser had a 60° angle on the driving face and a 30° angle on the forward face. This is how we made our extruded aluminum grousers (Exhibit B-4). I'm told that it's called a 'Kamm Wedge' but I've never seen it written up anywhere."

"During development, we tried a Kamm Wedge and compared it with flat plates commonly used. We found the Kamm Wedge to be far more effective in not picking up snow, in better flotation and with less tendency to scoop the snow out from under the tracks. What happens is that the 60° wedge is supposed to compact a ball of snow behind each grouser. This ball gives a larger shearing area and a greater shear reaction. At least, that's what I've been told."

John had worked with industrial designers at Hus-ski and liked working with them. He recognized that they could make a signigicant contribution to the design but economics preclued his using one on the Snotruk. He undertook the industrial design himself. His early sketches (Exhibits A-3 and A-5) show his concern for form and function. "We are departing from a recreational vehicle approach. They are designed to look racy and sporty. This is not the image we want to project. We want the Snotruk to look like what it is, a rugged work horse. Consequently, we made the vehicle look much like a truck, we made no effort to hide the working elements. No one has questioned whether the Snotruk is strong enough, quite to the contrary, they go out of their way to comment on its ruggedness."

As soon as the design was sufficiently developed to do so, John moved into prototyping. He knew that prototype testing was the only way to get the necessary information he needed to complete the design.

The first prototype (Exhibits B-5 and B-6) was basically a breadboard. It had the new suspension system, the engine location was fixed and the first drive system was used. It didn't have any cab and it had a Bolens Steering Mechanism. It was completed in the summer of 1970. There was no snow so the tests were run on sand.

Most of the failures on test were buckling and fatigue failures in the frame. These elements were strengthened. In some cases they were elements which John hadn't analyzed but had just put a piece in to get testing underway. In other cases the service loads were greater than anticipated. Tests also revealed some minor oversights in the design that only testing could reveal. John recalls, "We ran the first prototype until it wouldn't run anymore. Typically, it would run about 2 hours before something failed. After repair, it could run about another 2 hours before something else failed.

The second prototype (Exhibit B-7) was closer to the final design and it ran on the average about 4 hours between failures.

It was tested in the winter of 1970-71. Although not appreciated by the general public, the snowfall was excellent for snowmobile development. The snowfall came early and in large quantities without intermediate thaws and never developed any structure. It was ideal weather for flotation studies. The vehicle's steering was excellent but in the light snow the flotation was unsatisfactory. The Snotruk tended to sink deep into the snow under certain conditions.

To correct this, 14 inches was added to the length of the frame of the third prototype (Exhibit B-8). This permitted inclusion of an extra set of bogie wheels and 14 inches of additional track, reducing the ground pressure. At the same time a serious weight reduction program was undertaken. By adding lightening holes and by careful redesigning of various parts, such as brackets, etc., which had been hastily designed to get something going, the weight of the vehicle was reduced from 1200# to 950#. The weight was also redistributed so that there was less weight on the skis.

When the third prototype was tested, the steering was still excellent on both soft snow and hardpack and flotation was no longer a problem. This prototype was finally approaching what the unit would look like in production and ran about 25 hours before the first failures started to show.

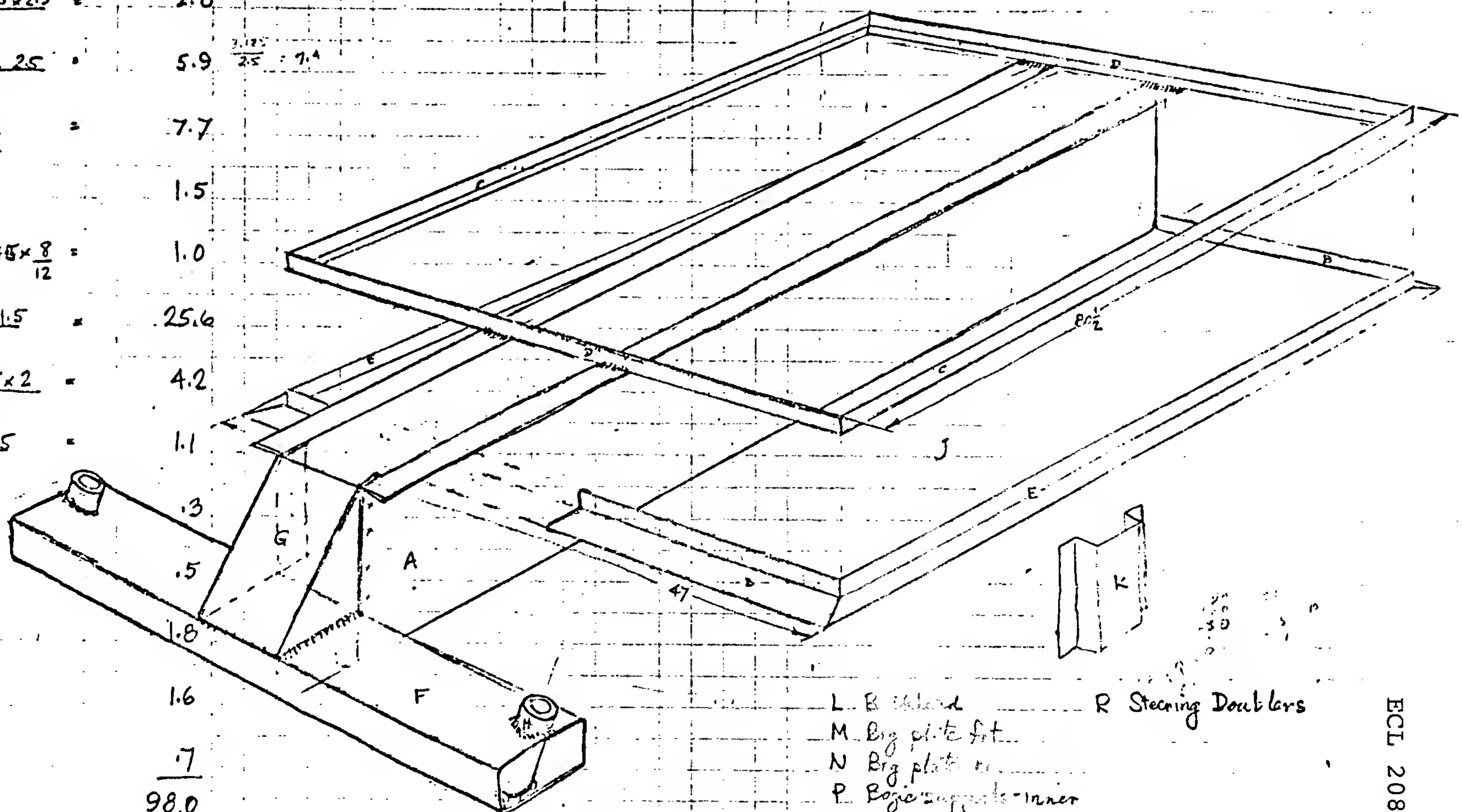
With prototype four (Exhibits B-9 and B-10), design was considered finished. It was as far as Nortrac could go with in-house testing. The average running time between failures was more than 50 hours. They couldn't think of how to break it through normal service. It was badly damaged when it was run into an ironwood tree but that couldn't be considered normal service.

For further useful testing, it would be necessary to build production units and sell them to selected customers who had an interest in the Snotruk and who would provide valuable feedback.

(6)

A ~ 18 ga ~	$\frac{26 \times 98}{144} \times 2$	=	33.5 lbs.
B ~ 16 ga ~	$\frac{2 \times 47 \times 3 \times 2.5}{144}$	=	4.9
C ~ 16 ga ~	$\frac{2 \times 70.5 \times 1.75 \times 2.5}{144}$	=	4.9
D ~ 16 ga ~	$\frac{2 \times 45 \times 1.75 \times 2.5}{144}$	=	2.8
E ~ 16 ga	$\frac{2 \times 84 \times 2 \times 2.5}{144}$	=	5.9
F ~ 16 ga (2x3)	$2.15 \times \frac{43}{12}$	=	7.7
G ~ 19 ga ~			1.5
H ~ 1" 10 x $\frac{1}{8}$ wall x 4 x 2	$1.45 \times \frac{8}{12}$	=	1.0
J ~ 20 ga ~	$\frac{9.5 \times 260 \times 1.5}{144}$	=	25.6
K ~ 18 ga ~	$\frac{6 \times 6.5 \times 7.75 \times 2}{144}$	=	4.2
L ~ 16 ga ~	$\frac{8.5 \times 7.6 \times 2.5}{144}$	=	1.1
M ~ 16 ga ~	$\frac{5.5 \times 3 \times 2.5}{144}$		.3
N ~ 16 ga ~	$\frac{7 \times 3.75 \times 2.5}{144}$		.5
P ~ 16 ga ~	$\frac{6 \times 17 \times 2.5}{144}$		1.8
Q			1.6
R ~ 18 ga.	$\frac{52 \times 2}{144}$		.7
			98.0

$\frac{3.125}{2.5} = 7.4$



L. Bulkhead
M. Brg plate fit
N. Brg plate
P. Bogie supports - inner
Q. " " - outer
R. Steering Doublers

Frame Layout

EXHIBIT B-1

EXHIBIT B-2

Front Ski Arrangement on Snotruk Showing Leaf Spring

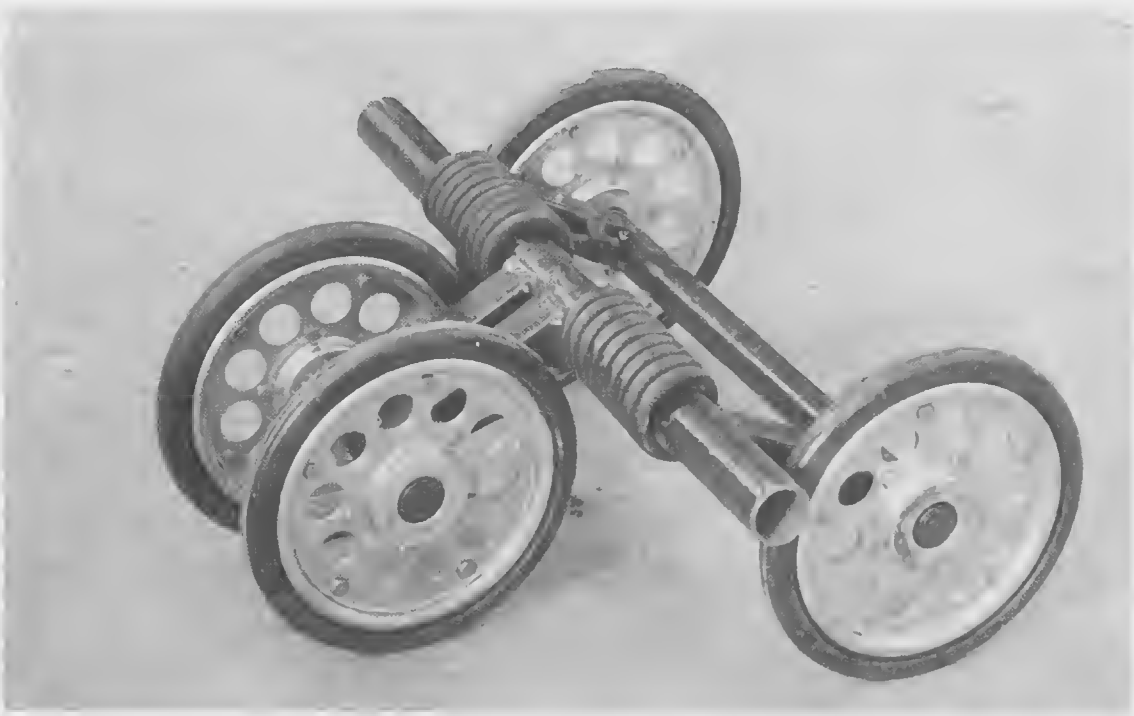
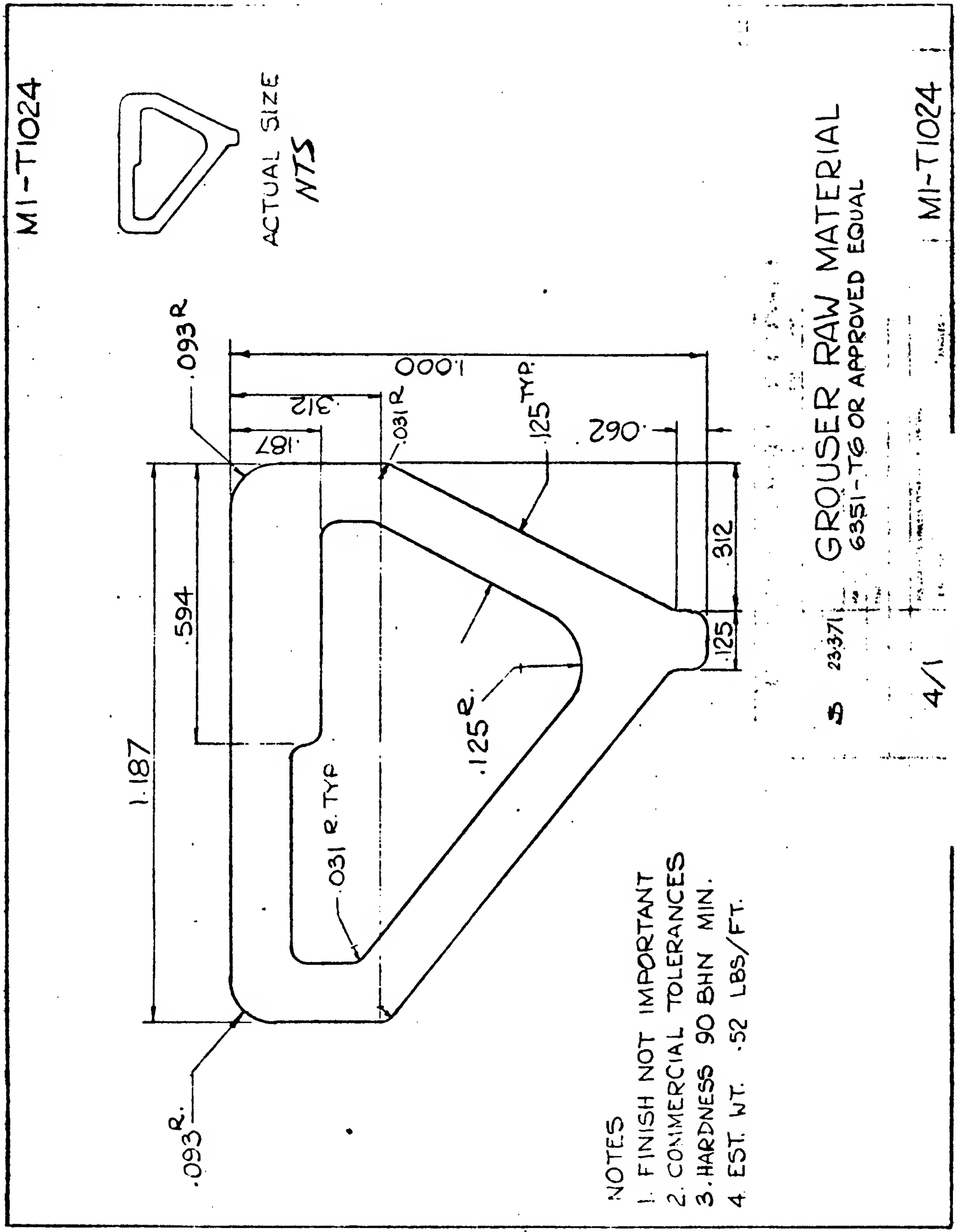


EXHIBIT B-3

Standard Bogie with Round Wire Spring



Grouser

EXHIBIT B-4

EXHIBIT B-5

John Smeaton Riding First Prototype

EXHIBIT B-6

First Prototype
Note: Ground Contact of Track

EXHIBIT B-7

Second Prototype

EXHIBIT B-8

Third Prototype

EXHIBIT B-9

Fourth Prototype

EXHIBIT B-10

Fourth Prototype Being Tested in Sand Pit

THE SNOTRUK (C)

Component Design & Development

When the design started, John had hoped to use a large number of stock parts as do most small producers of recreation snowmobiles. This was not possible to the extent originally planned. Components of the size and capacity the Snotruk required were not available. John ended up having to design and develop a large number of these components himself, such as the transmission and the brake. Others, such as the engine, could only be adapted after considerable testing. The initial hope of taking advantage of proprietary producers' developments was not fully realized.

Added to this, because prototype quantities were small and eventual production quantities not particularly large, John found that he was restricted in choice of design alternatives, because suppliers of castings, springs, etc. were not interested in small quantities and because tooling costs were excessive. A case in point was his need for square-wire springs for the rear bogies of his novel suspension system. His simple, elegant solution caused him difficulty. Round-wire for springs is standard stock, the square-wire is special. Delivery of John's square-wire springs was thus dependent on a mill run of the square-wire becoming available. The quantity he uses is not sufficient that he be given special consideration so he finds he is at the mercy of the wire supplier.

Engine Development

After the basic layout of the vehicle was established, the next important component was the engine. It had been decided early that a two stroke engine would be used, primarily because John and the staff had experience in handling two stroke engines and because they were relatively low cost and light. John's calculations showed that for a speed of 20 mph his Snotruk would need about 25 hp.

This proved to be the first difficulty. There wasn't a complete engine package available which would be suitable. There were two stroke engines powerful enough but they were designed for high speed operation with very peaked torque speed characteristics. The early snowmobiles had adapted German designed industrial two stroke engines. These engines had been sturdy engines, designed for steady load and long life. After 1969, the snowmobile market had become the major outlet for the

engine manufacturers and their newer designs are tailored to recreation requirements.

Recreational vehicles normally need a light, high speed engine which develops maximum horsepower at high rpm. Engine durability is sacrificed for performance. The owner of the recreation vehicle is interested in a thrilling, exciting ride which usually means high speed. This sells recreation vehicles.

With the variable speed belt drive used on snowmobiles, there is a limit to the speed variations possible. With a top speed of 40 mph the engagement speed of the clutch has to be 8-9 mph. This would be unsatisfactory in John's application. The Snotruk is required to inch along and a much lower engagement speed is necessary. The engine needed must develop a reasonable torque at a lower speed.

The typical recreation vehicle engine doesn't develop appreciable torque until about 4000 rpm, peaking out at 6000 rpm and overspeeds to 7500 rpm. This didn't suit John, "We might have been able to make it work but the user would never accept it even if it did work. He'd feel that the engine was ripping itself to pieces. It's a question of aesthetics. Aesthetics isn't just visual form, it is also making the product sound and feel like the user thinks it should. It's the total harmony." The search for a suitable 25 hp engine at first was discouraging. The standard snowmobile engines which could develop the necessary horsepower, were light, high speed engines.

After many inquiries, John contacted the Canadian sales representative of JLO, a German engine manufacturer. JLO is a division of North American Rockwell Co. When Dr. Pepinghaus of JLO last designed a larger horsepower engine he had done so using the principles for industrial engines, consequently, his engine was rugged and relatively heavy, unsuitable for recreation vehicles but ideal for John. Only two hundred of the engines had been sold, not enough to pay for the development, and 1000 sets of components were still available at JLO which they were prepared to let Nortrac have at a reasonable price. The price and performance of the engine seemed right so John decided to use it in the Snotruk.

Once the engine was received it had to be adapted. One of the reasons John had chosen a two stroke engine was that the speed torque characteristic could be modified very simply by tuning the exhaust system. The first muffler tried was one supplied by the Donaldson Co. and designed for this engine. With it

the engine produced 15 hp. After trying other standard mufflers, John found he could get anywhere from 15 hp with very horrible torque characteristics to 40 hp with a very peaked power curve. It quickly became apparent that John would have to develop his own exhaust system.

Carleton Products Consultants Ltd. had done some muffler work for Bolens but nothing as extensive as this. The exhaust system had to be designed so that the engine gave 25 hp with a flat torque speed curve without excessive piston temperatures and with the noise levels below 85 db. John started with a literature search at the National Research Council Library, in Ottawa, to see if he could find anything. Outside of a few papers in SAE Journals reporting on Japanese experiments, there wasn't much available.

John therefore put an engine on a dynamometer, instrumented it with thermocouples to measure cylinder head temperatures, and had his technicians run a series of experiments with various mufflers. "The Japanese work gave a great deal of detail but not in a form that most designers can understand or use. Like so many technical papers, they were completely useless to the designer. We started with some rules of thumb which we found in a book on motorcycles which told what direction to move in if you know your starting point. But there was really no substitute for putting the engine on the dynamometer and cutting pieces off or adding pieces on the muffler, in a sensible way of course."

"The changes may seem a little like black magic. For instance, to show how things can be juggled let us take as an example an exhaust consisting of simple straight pipe. The longer you make the pipe from the piston face the lower will be the speed at which you develop peak torque and peak horsepower. Flaring the end of the pipe changes the characteristics considerably. A cone on the end of a pipe on an engine which normally has a sharp torque peak at 5000 rpm, will cause the engine to still have the peak torque at 5000 rpm but the curve is much flatter, producing approximately the same horsepower from 4500 to 5500 rpm. But this change will cause cylinder temperature to go way up. If, instead of a flare, the exhaust pipe is blocked at the end and holes are pierced in the pipe walls,you get a different result with respect to peakiness."

"With industrial engines and with our application you try to have maximum torque over as wide a speed range as possible and keep the piston and cylinder temperature as low as possible. Thus the object is to design your own exhaust system

to get power where you want it, to maintain engine durability (low temperature), and to get lowest possible noise level."

By the time a satisfactory exhaust system had been developed, Nortrac had spent $5000 on dynamometer testing and muffler prototyping.

Once the exhaust system was developed the engine proved to be reliable and gave no trouble.

Power Train

Since a large percentage of snowmobile manufacturers purchased the power train components, gear boxes, V-belt transmissions, brakes, clutches, etc., from proprietor manufacturers, it was expected that the Snotruk would also be equipped with such purchased components. But the Snotruk was sufficiently different that this approach had to be abandoned. Ultimately many of the power train components had to be designed by John Smeaton.

Fortunately, John's experience with standard snowmobile elements, a little ingenuity, and sound design analysis from standard texts permitted him to extend the designs of recreation vehicles to meet his new requirements. "Our major innovations in the Snotruk are extensions of our experience in recreation vehicle design to the commercial vehicle. We have taken the smaller vehicle and made it larger. For tooling reasons alone we had hoped to use a large number of stock components but on close examination these components proved to be woefully lacking."

On the Snotruk, as in most snowmobiles, the engine drives the gear box through a variable-speed torque sensitive V-belt drive (Exhibit C-1). The torque is automatically adjusted by a pair of centrifugally operated variable pitch sheaves. The system is torque sensitive and changes drive ratio dependent on load. When the engine idles the belt slips and acts as a clutch. A suitable variable V-belt drive was available and needed no development other than sizing the components.

The Snotruk required a simple forward and reverse transmission. When John received sample gear boxes, supposedly adequate for the service, he took them apart and analyzed the gears. It was obvious that the gears would never transmit 25 hp continuously. According to John, "We needed 90 ft. lb. torque input. None of the sample boxes we received could handle 50 ft. lbs. for any length of time. I knew then that we would have to design the final stage of the drive, so at this point it seemed logical to integrate the entire drive system into a single transmission."

The transmission was designed into an aluminum housing with a three shaft arrangement (Exhibits C-2 and C-3). John describes the unique features of this transmission as follows, "The cost of a gear box is approximately proportional to the number of shafts you have in it. The shafts and the associate bearings make up a large part of the cost. Our objective was to get a double reduction at least 5:1, with a single speed forward and a reverse with only three shafts using simple spur gears or transmission chain sprockets. Normally a fourth shaft is used to look after reverse."

"We decided the forward drive would be a chain because a chain is quieter, readily available and it is not very sensitive to centre distance. The chain and sprocket capacity were determined from the catalogue ratings. Actually we are running them at twice the recommended catalogue capacity. The ratings are ultra conservative. Most snowmobile applications actually operate at 10 times the rated capacity with little trouble. Then, having a gear for reverse direction, it was easy to use the same shafts, since chains drive a pair of shafts in the same direction and gears drive them in an opposite direction."

"The selection for forward and reverse was accomplished by a simple piece of original design I am pleased with. The drive sprocket and gear are allowed to float on the shaft. There are oilite bushings on the inside of the sprocket and the gear. A hexagonal element is pinned to the input shaft between the gear and sprocket. A sliding dog with a hexagonal bore and a jaw clutch at each end floats on the hexagon. A lever is used to move the sliding dog so that the jaw clutch engages either the gear or the sprocket depending on whether forward or reverse is selected."

"There are all kinds of compromises which one must make in design. In the design of original, low cost equipment, like the Snotruk, one finds that many times the design is dictated by the money available for investment in tooling. It's one thing to know the best way to design something for performance, it's entirely another thing to know the best way to design something for a given production run. The aluminum housing for the transmission as an example, we could have made a much better design (lighter, etc.) if we could have used permanent mold casting. But the tooling would have cost $10,000, so it wouldn't have made good business sense to attempt to amortize this over 100 vehicles.

"For a small company like ours most suppliers just don't want to talk to us because of the small quantities. We are

fortunate to have good relations with Harrington Foundries in Woodstock. It's a family business and I deal with the owner all the time. They only make aluminum sand castings and even here they don't like to pour anything but their standard alloy with which they are familiar. Thus the transmission is an aluminum sand casting of standard alloy."

The brake is mounted outside the transmission box on the idler shaft extension (Exhibit C-3). The brake was also expected to be a purchased item. A number of brakes were purchased and tested. Because of the limited space available, large automotive brakes would not have been suitable.

One of the brakes, a drum type, had been designed for use in golf carts where the speeds were low and the panic stops were not necessary. This brake just didn't have the necessary torque. Another brake, a disk type, had sufficient torque when tested but the high temperatures generated reduced brake life drastically. On test this brake had to be adjusted after every 100 stops and it was completely worn out after 500 stops. Clearly the commercially available brakes would not do and one had to be designed.

In designing his brake, John once more took a simple straight forward approach. He decided on a band brake. The design criteria and method was taken directly from Design of Machine Elements, by Faires (Exhibit C-4).

"We first designed the brake to be self energized in the forward direction. We found on test that we couldn't properly control the amount of self-energization. You are supposed to be able to, in theory, but we found that the slightest flexibility in the system would lead to disastrous results with the brake grabbing. If the return spring were to break, it wouldn't be able to be de-energized at all. We redesigned it so that it was no longer self energized. A simple mechanism, which no one thought would work, was developed for adjusting for wear."

The brake which John designed had greater stopping power than the brakes which had been purchased and it fit into the same space. On test, the brake went through 5000 stops without appreciable band wear.

The first prototype brakes worked satisfactorily. When a second set was made, the drums began to fail on test. John searched for the cause. "This was another example of problems you can have as an entrepreneur developing a new piece of equipment with limited facilities and money. The original

SALSBURY

How It Works:

MODEL 910
Torque Sensitive
Type Converter

OPTIONAL PULLEY BORE SIZES, TAPER, OR INTEGRAL SHAFT

OPTIONAL BRAKE COMPONENTS AVAILABLE

STRONG LIGHTWEIGHT SHEAVES

AT IDLE
(In "Neutral")

At idle, the driver pulley is at the reduced engine speed, the driven pulley is stopped. Note the belt is not under tension.

STARTING
("Low Gear")

During start up, the engine operates at a medium to high speed, the driven pulley at a slow speed for a maximum torque ratio.

HIGH SPEED
("High Gear")

As speed increases the converter upshifts smoothly and infinitely to a 1:1 ratio or overdrive for maximum speed and cruising economy.

page 4

Two types of driven pulley systems available:

SPEED SENSITIVE

At low speeds the normal position of the driver pulley maintains the V belt at a smaller diameter which with the corresponding larger diameter on the driven pulley, creates a "low gear" ratio.

As the speed increases, the centrifugally activated roller weights (A) follow the contour of the bowl shaped ramp plate, forcing the driver sheaves together. This action through the belt compresses the driven pulley spring (B), thus achieving a "high gear" ratio.

TORQUE SENSITIVE

page 5

EXHIBIT C-1
Salsbury Variable-Speed Drive

DATE NOV 15/72

ECL 208C

DEPT.	NAME

SALSBURY INDUSTRIES

CUSTOMER SPECIFICATION
800 SERIES

CUSTOMER NORTRAC MFG LTD BY H. FLORINSKI
251 5th ARNPRIOR - ONT
PHONE 603 623 6101
CONTACT JOHN SMEATON TITLE PRES CUSTOMER APPROVAL [signature]

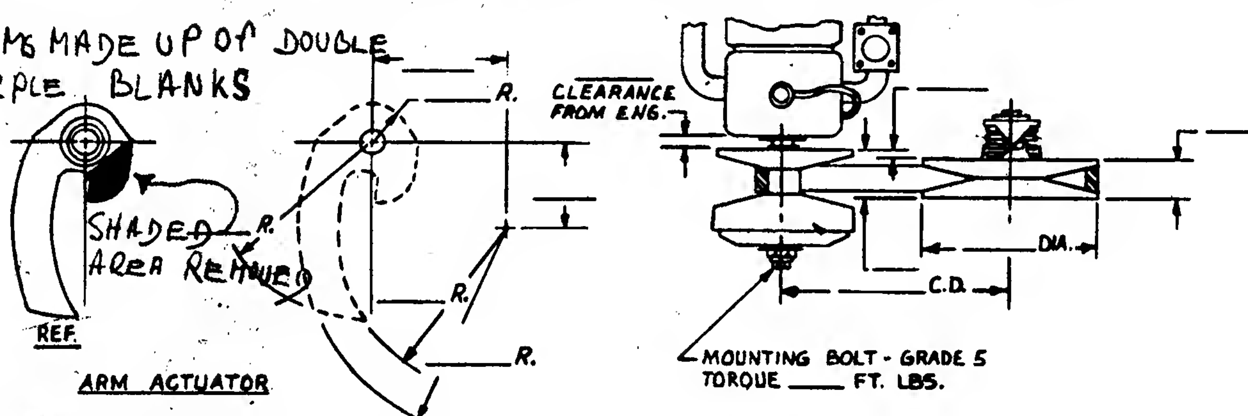
TYPE OF APPLICATION COMMERCIAL SNOWMOBILE MODEL ______ YEAR 1972/73
PREFERRED ENGAGEMENT RPM BELOW 3000 PREFERRED OPERATION RPM 5000
ENGINE BRAND ILO LR 760-2 HP @ 38.5 RPM 5000

DRIVE CLUTCH:

MANUFACTURER SALSBURY MODEL 860 PART NO. ______
BORE 30 mm FLUSH INSET / OFFSET.

PART NUMBER	DESCRIPTION			
	ROLLER DIAMETER	11/16	COLOR CODE	BROWN
	ARM ACTUATOR	SPECIAL	COLOR CODE	
	CENTER SPRING RATING	84 LBS	COLOR CODE	GRAY

ARMS MADE UP OF DOUBLE PURPLE BLANKS



DRIVEN CLUTCH:

MANUFACTURER SALSBURY MODEL 860 PART NO. ______ DIA. 11 1/4"

PART NUMBER
703 102

DESCRIPTION
TYPE OF BRAKE ☑ SEPARATE ☐ FLANGE ☐ FLANGE LIP ☐ DRIVEN DISC ____ DIA.
SPRING WIRE DIA. ______ NO. OF COIL 7 PRE-LOAD 120° COLOR CODE YELL.
RAMP CAM ANGLES ______ DEGREES 32° COLOR CODE BLACK
BORE 7/8" KEYWAY 3/16 #

BELT SPECIFICATION:

MANUFACTURER ______ PART NO. ______ CUSTOMER PART NO. ______
O.C. ______ P.L. ______ T.W. 1 1/4" ANGLE ______
TYPE OF C.D ADJUSTMENT ☐ FIXED ☐ CAM ☐ SLOTTED
TYPE OF OFFSET ADJUSTMENT ☐ FIXED ☐ CAM ☐ SLOTTED
BELT CENTER DISTANCE 10 9/16 ± ______

FIELD TEST DATA:

GROUND CONDITION ______ GEAR RATIO ______
WEATHER ______ TRACK & SIZE ______
MAX. SPEED 2" SNOW ______ MAX. SPEED HARDPACK ______

COMMENTS: ______

M - 72-2

EXHIBIT C-1

Specification Sheet for Purchased
Variable-Speed V-Belt Drive

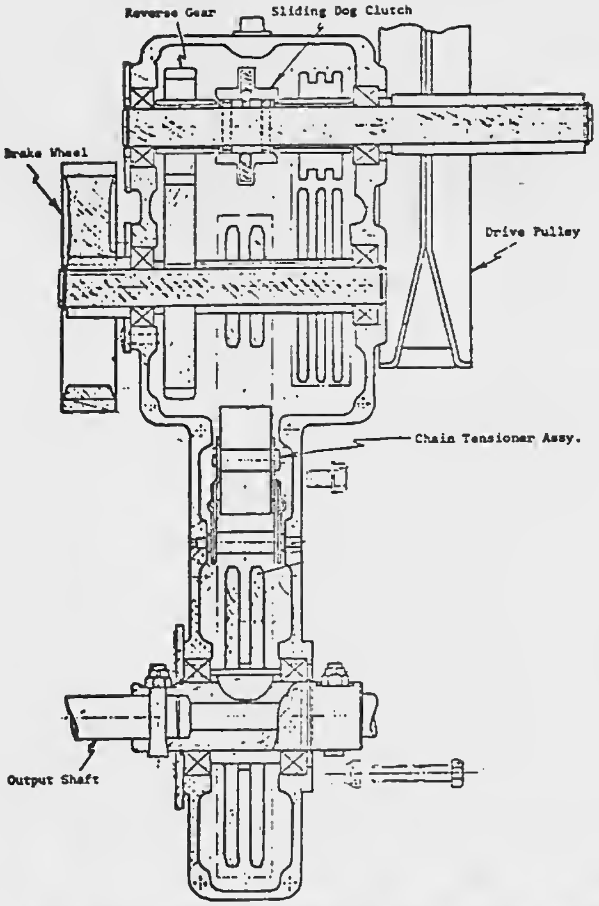


EXHIBIT C-2

Sketch of Transmission Box Showing Principle Components

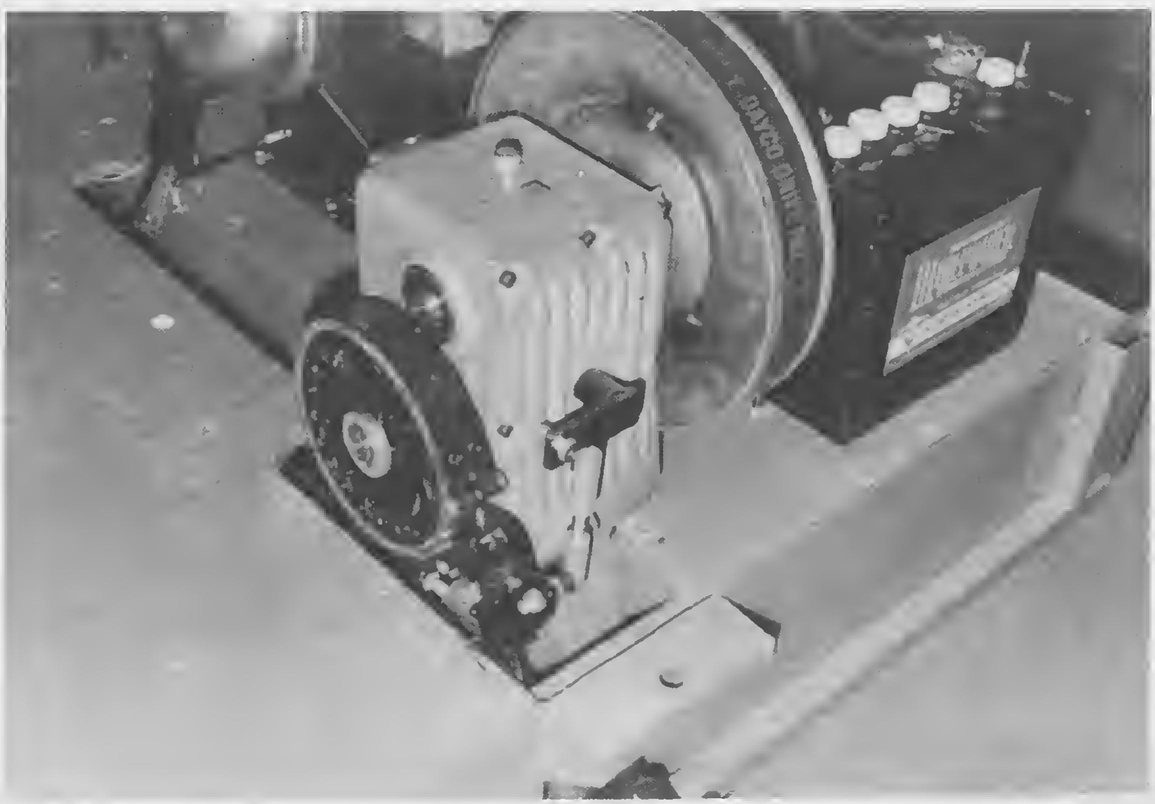


EXHIBIT C-3

Transmission Box Mounted on Snotruk Showing Brake on Near Side

brake wheel (Exhibit C-5) had been specified as simple grey cast iron, a tensile strength of 30,000 psi was assumed. We had a wooden pattern made and a small foundry in Renfrew made the first 25 castings for us off the pattern. When we machined these we found a number had blow holes in them and they could not be used. So we looked around for a larger foundry with better quality control."

"The only cast iron foundry left in our area was in Carleton Place. When we approached them with our small order they weren't interested. Most foundries today are not interested in small quantities such as 100 castings. If we had 10,000 castings to make with 50% of the final cost down, they might be interested, but not particularly excited. Finally, one of our machinists (a shareholder) spoke to a friend at the foundry and on this personal basis the foundry took on the job. When we put the brakes made from these castings on test, they failed. Comparing the part with the drawings, we found that the pattern maker had mistakenly put a 1/8th inch radius at the hub instead of the 1/4 inch specified on the drawing. But this could not have been the cause of failures because the original castings had the same error. Our tests were consistently snapping these new castings off."

"I called the technical manager at the foundry who said, 'Bring the pieces up and show them to me.' I made an appointment to see him on a day he was to be free. When I arrived I cooled my heels in the waiting room for an hour and a half and then only the foundry foreman came to see me. I never did get to see the technical manager. It was pretty hard to realize I was the customer."

"My explorations with the foreman revealed that the parts had been made as grade 20 castings with a tensile strength of 20,000 psi instead of the grade 30 I had expected. They agreed to make the castings in grade 30. The experience wasn't a total loss. I found out that a simple inspection technique could be used to determine if the castings were grade 20 or 30. If you ring the casting, the grade 20 iron has a much duller tone."

The output shaft of the transmission box is connected directly to the track drive. Since both tracks are driven at the same speed no differential is necessary.

These power train developments were of course carried out concurrently with the engine development and the development of the remainder of the vehicle. Several versions were tested on the prototypes. By the time Nortrac was ready to build the first production units, the component designs had been tested and proven reliable.

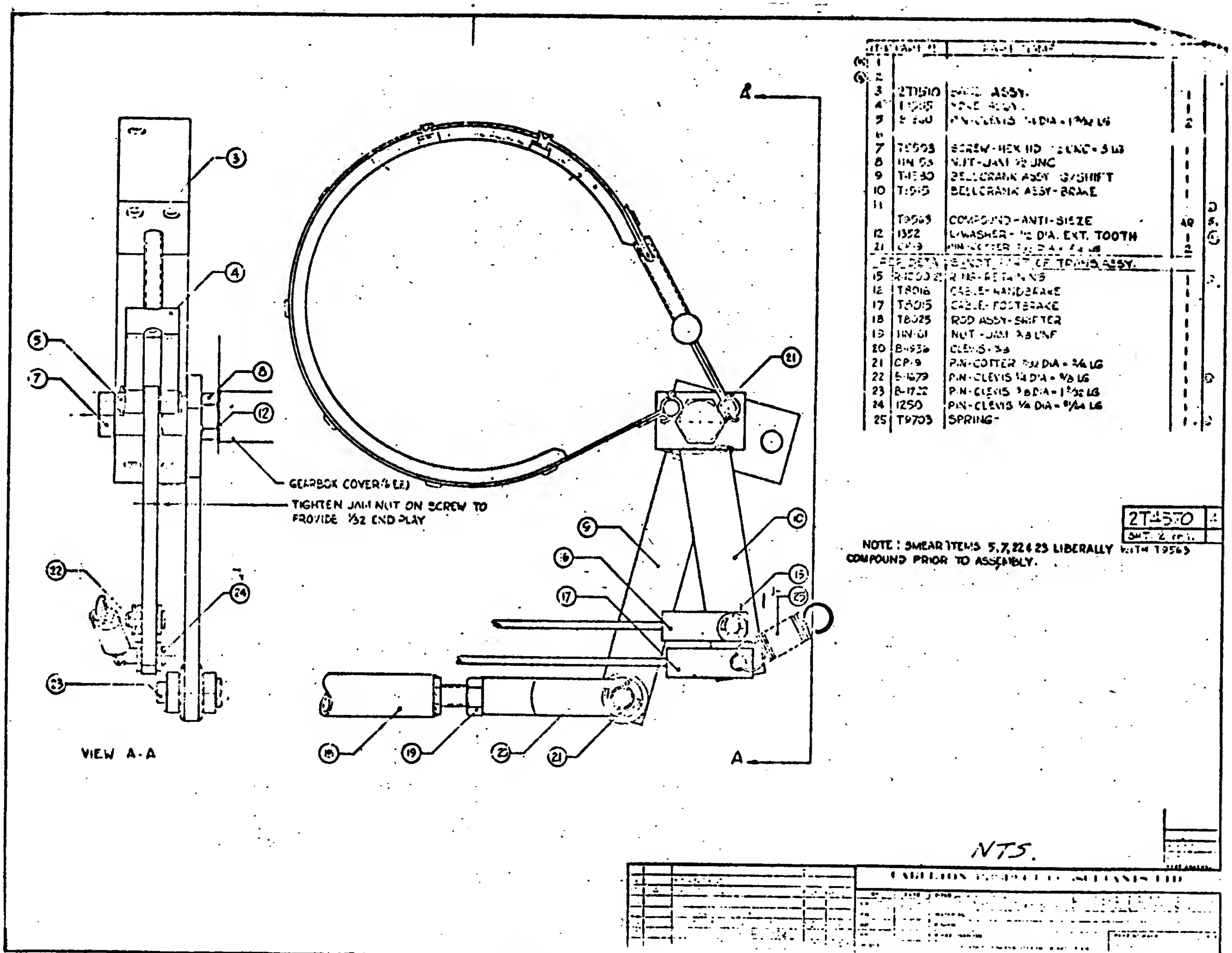


EXHIBIT C-4

<u>Brake Details</u>

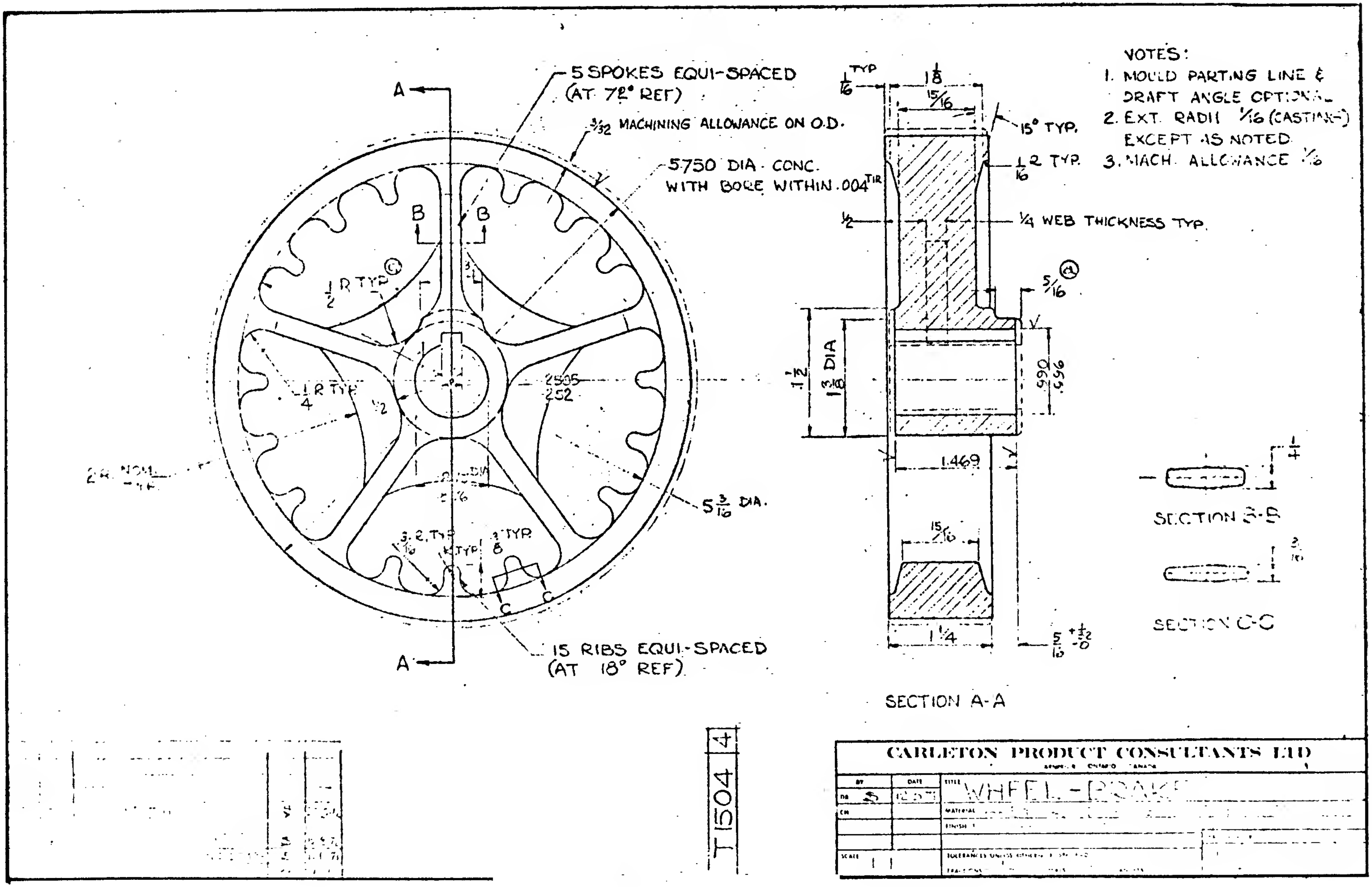


EXHIBIT C-5

Brake Wheel

THE SNOTRUK (D)

Production

In January 1972, with the prototype testing completed, 10 production Snotruks were built to the final design and sold to selected customers for evaluation. Among these were the Canadian Parks Branch of the Department of Northern Affairs. Customers were told that these were first production units. John and Fred expected that a great deal of service would be needed to keep them operating but the field experience was necessary.

Several of these customers allowed Nortrac to take the vehicle back into their shops after being in service for the winter and strip them completely to assess any wear or failure. This was most valuable since each customer used his vehicle in a different way.

Throughout the customer trials, Fred Fassbender maintained a continuous liaison. He insured that the vehicle operation was satisfactory. His discussions with the user generated a continuous feedback as to shortcomings and strengths of the design. Similarly, if the customer was having difficulty because he didn't understand the operation of the vehicle, Fred was there to instruct him.

The army was the most rugged user of the vehicle. They often, quite correctly, forced their own test criteria on the vehicle. In most cases their comments were valid and the part which failed was redesigned. In one or two cases, Fred and John after studying the recommendations and complaints, would have to reject them as being too severe a requirement for normal commercial use of the vehicle although no doubt necessary for the application envisaged.

Once units were in the field complaints came in from the operators that they weren't powerful enough. Tests and demonstrations showed that the vehicles had the specified load capacity and drawbar pull. In spite of this, the operators maintained that the engine wasn't strong enough. After considerable investigation, it was concluded that operators don't concern themselves with drawbar pull. To them a snowmobile is "powerful" only if the engine can spin the tracks. Even when the Snotruk could generate more than the necessary drawbar pull, if the tracks didn't spin before the engine stalled, the engine wasn't "powerful" enough.

Because of the difficulty he had in locating the original 25 hp engine, John gave serious consideration to using a small four stroke automotive engine in the Snotruk. The problem was resolved when JLO volunteered a new 38 hp two stroke engine in place of the 25 hp engine which he was using. A standard muffler on this engine worked perfectly.

On the basis of the feedback received from the customers of the first production vehicles, about 50 minor changes were made in the design. Some of the customer changes were concurrent with redesigns necessitated by further analysis, material changes and production engineering.

By August 1972, John and Fred were prepared for the coming winter season (Exhibit D-1). "We're just setting up dealers now for our first full commercial selling year. The first production units had been built in late January 1972. We're planning to run 100 vehicles for the coming winter. Our major problem now is marketing."

With a break-even point of 200 vehicles a year, additional work was necessary for the shops to keep the company going. Nortrac contracted to manufacture steel trailer frames. John does not find this work very satisfying from the innovative point of view, but it does provide the cash flow which keeps the operation going. "My principle concern these days is to meet the paychecks when they come due," says John.

As to the future, John does expect competition. The market is open to be tapped. In his eyes a mark of his success as an innovator will be whether he does have competition. He still has his eye on the specialty market and expresses his objectives as follows.

"What we'd like to do is to give outstanding service to a limited number of customers. Instead of just supplying them with a snowmobile, we'd like to sell them a complete engineered package which will do their job as long as it has something to do with going across snow. We look upon the Snotruk as a basic unit around which we can supply all kinds of accessories. Besides this kind of engineering is more fascinating than just cranking out different models of snowmobiles, year after year."

"It makes commercial sense. Fred agrees with this point of view. He can make use of his talent for customer liaison by establishing the special requirements. This way we can both do our thing while operating a commercially viable industry."

"True, we are essentially in business to make money, but more than that Fred and I and the other employees are individuals and we want to have a good life, which to us means doing our own thing. We do recognize that we have shareholders and we must keep them happy. We ourselves don't need large sums of money. So what it means is we can work for relatively small, fixed salaries and take our bonuses out of our share of company income which makes the other shareholders happy too."

EXHIBIT D-1
Snotruk Promotional Literature

NORTRAC

CAB ENCLOSURE

Increases working range of SNOTRUK during adverse weather conditions.

Ward off wind chill and cold fatigue. Extend your work capability. This cab features a fibreglass roof, sturdy steel-framed hinged doors, a laminated glass windshield, to ensure clear vision, even at night. A snap-on, roll-up, rear cab curtain of low temperature fabric provides easy ventilation adjustment.

HEATER

8,000 B.T.U. Gasoline unit. A truly efficient *additional* heater which runs independent of the SNOTRUK power plant and standard heating unit. It changes the air in the cab every 40 seconds, allows pre-heating of the cab and maintains "in cab temperature" well above freezing even during extremely cold weather conditions.

EXHIBIT D-1
Snotruk Promotional Literature

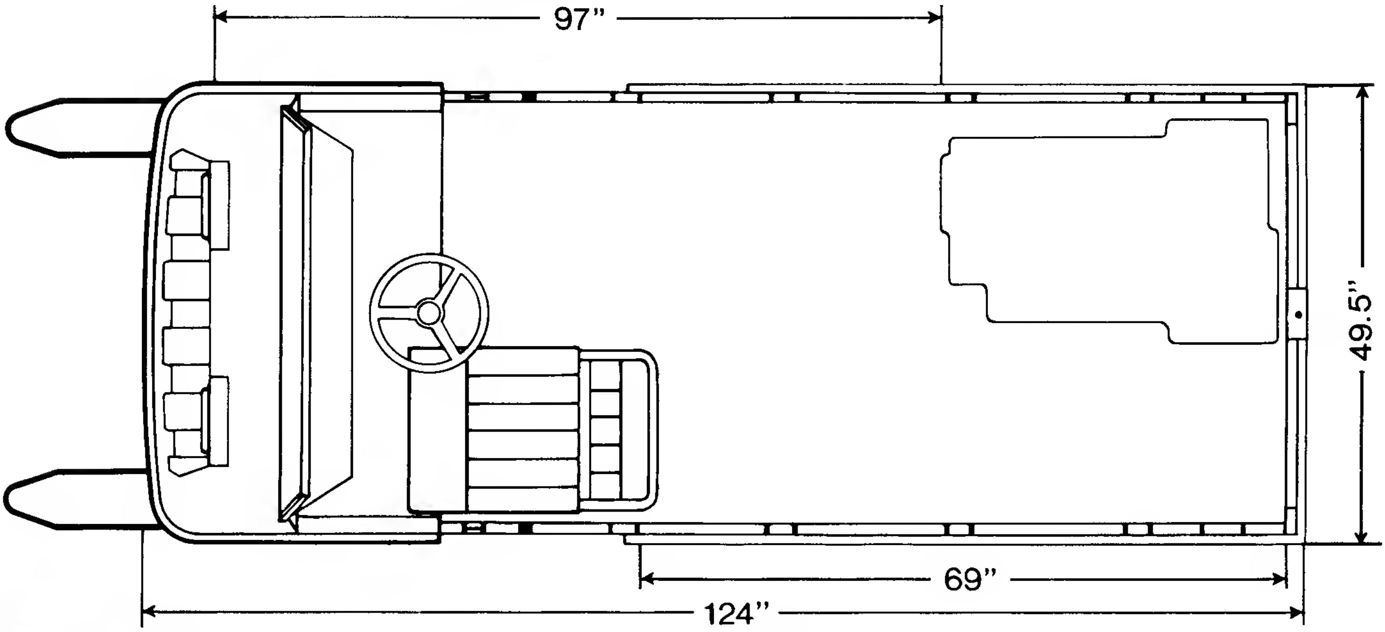
MANUFACTURED BY NORTRAC MANUFACTURING LIMITED, ARNPRIOR, ONTARIO

Specifications, Dimensions and General Information

SNOTRUK, CAB and HEATER

ECL 208D

(Adaptable to all SNOTRUK models).



SNOTRUK

Net Weight	1,000 lbs.
G.V.W.	2,000 lbs.
Speed	2-23 m.p.h.
Track area (effective)	2,700 sq. in.
Ski area (effective)	500 sq. in.
Ground pressure (laden)	.75 lbs./sq. in.

STANDARD FEATURES

Rockwell-JLO 600cc 2 cyl. engine, 24 bhp/4,500 rpm
or
Rockwell-JLO 760cc 2 cyl. engine, 34 bhp/5,000 rpm

Heavy duty electric starting system

440 watt alternator

Gearbox with forward, neutral and reverse

Automotive headlights with H-L beam, parking and tail-lights

Dual controls, operational from either side

Forced-air heating to cab, standard

Tow-hitch, front and rear

CAB

Windshield—laminated glass

Doors—tubular steel frames, cold weather latches canvas covered, large windows, open wide and instantly removeable

Backflap—snap-on, roll-up canvas with large window

Roof—fibreglass with provision for flasher installation

HEATER

Additional to standard vehicle heating

8,000 B.T.U.—operates independent of engine—gasoline fueled

Additional options include :

Electric winch (2,000 lbs.-50 ft.)
Various instrumentation
Additional passenger seats
Extra-large fuel tanks

NORTRAC MANUFACTURING LIMITED, Arnprior, Ontario, K7S 3H6 Canada
Telephone 613-623-6101, Telex 053-3774

The manufacturer reserves the right to change specifications at any time without notice

EXHIBIT D-1
Snotruk Promotional Literature

YOUR NEAREST
SNOTRUK DEALER :